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Relation Among the Analyzed, Initialized, and Postprocessed Values of the Relative Humidity Produced by the LFM, and a Possible Code Change

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RELATION AMONG THE ANALYZED, INITIALIZED AND POSTPROCESSED VALUES OF THE RELATIVE HUMIDITY PRODUCED BY THE LFM AND A POSSIBLE CODE CHANGE

1. Introduction

In NMC Office Note 140, R. Chu described the methods used to construct the LFM relative humidity analysis. Additional processing takes place before the analyzed relative humidity is used by the forecast model and prior to the production of the postprocessed values of the zero-hour relative humidity. Since the additional data processing changes the value of the analyzed relative humidity, it is important that users of the forecasts and the postprocessed fields be aware of these steps.

2. Initialization

The LFM model accepts the analyzed fields of relative humidity for the three lowest σ layers of the model. These values are used in conjunction with the analyzed values of temperature, pressure and geopotential to produce fields of actual and saturation values of precipitable water in each of the model's three lowest σ layers.

In carrying out the construction of the initialized fields of precipitable water, the model's use of a "reduced" saturation criterion is taken into account. This criterion involves the model approximation that cloudiness and precipitation is observed to occur even though the relative humidity depicted with the resolution afforded by the model grid system indicates a value less than 100%.

The LFM is presently coded to modify the actual and saturation values of precipitable water, that correspond to the analyzed temperature and relative humidity, so that the values carried by the forecast model are compatible with a seasonably variable "reduced saturation criterion" denoted by the parameter SATRH. The seasonal variation of SATRH is given on page 8 of Office Note 140. During the summer SATRH = .90; during the winter it is .96.

Let RHA_k be the analyzed relative humidity in σ layer k (k=1,2,3). Let WSA_k be the saturation value of precipitable water in σ layer k corresponding to the initialized values of potential temperature and pressure in σ layer k. Let WA_k be the precipitable water in σ layer k corresponding to WSA_k and RHA_k,

$$WA_k = RHA_k * WSA_k.$$

The model initializes the saturation value WSA_k by multiplication with the current value of SATRH. We denote the initialized saturation value of precipitable water WS_k. The code writes

$$WS_k = SATRH * WSA_k.$$

Since it is possible for RHA_k to exceed SATRH, the value WA_k is replaced by an initialized value W_k by writing

$$W_k = \text{minimum } \{WA_k, WS_k\}.$$

In this way the value of W_k can never exceed WS_k.

3. Postprocessing Relative Humidity

The fields of relative humidity that are produced by the LFM model at the initial time and subsequently, are constructed from the values of W_k and WS_k be writing

$$RH_k = W_k/WS_k.$$

It is important to observe that the field of RH_k will generally differ from the field of RHA_k. The difference varies with season because SATRH varies with season. The relationship between RH_k and RHA_k may be expressed as follows.

(1) If $RHA_k \geq SATRH$, $RH_k = 100\%$

(2) If $RHA_k < SATRH$, $RH_k = (RHA_k/SATRH)$

In every instance the values of RH_k will equal or exceed the analyzed relative humidities. This effect is called "inflation". Provided that $RH_k < 100\%$, one may recover the analyzed value by use of (2). It is impossible to recover the precise value of RHA_k should it exceed SATRH.

4. Differences Between the 6L PE and the LFM

The 6L PE uses a seasonally uniform value of 90% for the parameter SATRH. The humidity analysis used by the 6L PE comes from the global spectral analysis code described by D. Parrish in Office Note 140.

The initialization of the 6L PE model* parallels the LFM method outlined above with one significant exception. The 6L PE reduces the analyzed relative humidity RHA_k south of 25°N latitude by multiplication with $2*\sin\phi$, where ϕ is the latitude. The relative humidity produced is not permitted to be less than 20%. A comparison of the 6L PE relative humidities before and after this "low-latitude adjustment" shows that major changes are produced.

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*The current 6L PE initialization procedure is apparently undocumented in the Technical Procedures Bulletins.

5. The LFM's Use of the 6L PE Forecasts

We must note here an apparent inconsistency in the LFM humidity analysis code's use of the 12 hour forecast humidity produced by the 6L PE. On page 8 of Office Note 140, it is recorded that the 6L PE forecast values are "deflated" by the LFM analysis code. The "deflation" is now done using the SATRH parameter appropriate to the LFM (seasonally variable between 0.9 and 0.96) rather than using the SATRH value of .9 appropriate for 6L PE data which is apparently a more "correct" method.

We may now ask whether or not this inconsistency can be significant. Clearly it can make no difference in the summer months May-September during which period both the 6L PE and the LFM use the SATRH value .9.

During the winter the LFM uses SATRH = .96 whereas the 6L PE uses .9 for SATRH. Consequently the LFM humidity analysis code now uses .96 of the 6L PE forecast relative humidity where it should use .90 of that value. Thus the LFM over estimates the 6L PE's relative humidity forecast by the ratio .96/.9 or 6 2/3%. One has the table:

6L PE Forecast RH	LFM Analysis Interpretation	
	Now	'Correct'
100	96	90
90	86	81
80	77	72
70	67	63

We have seen in section 3 that the output values of relative humidity from the LFM are in general "inflated" in comparison with its analyzed values. We may next compare the impact of the inconsistency just noted on the output LFM RH's:

6L PE Forecast Relative Humidity	LFM Analysis Now	LFM Analysis 'Correct'	LFM Output Now	LFM Output 'Correct'
100	96	90	100	94
95	91	86	95	90
90	86	81	90	84
85	82	76	85	79
80	77	72	80	75
75	72	68	75	70
70	67	63	70	66

From this table above, we see that the method now used has the virtue (?) of yielding consistent values in the two models' output relative humidity fields provided that observed data doesn't over-ride the 6L PE forecast value in determining the LFM analysis-initialization.

The principal use of the 6L PE humidity forecast by the LFM humidity analysis code is to provide reasonable estimates of the humidity over oceanic areas, principally the eastern Pacific Ocean. In view of the known bias of the LFM to overforecast precipitation in the western portion of the United States, it would appear marginally advantageous to change the LFM analysis code to produce the 'correct' use of the 6L PE model's forecast relative humidities.